Atmos. Chem. Phys. Discuss., 4, S2647–S2651, 2004
www.atmos-chem-phys.org/acpd/4/S2647/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

ACPD

4, S2647–S2651, 2004

Interactive Comment

Interactive comment on "Modelling the impact of noctilucent cloud formation on atomic oxygenand other minor constituents of the summer mesosphere" *by* B. J. Murray and J. M. C. Plane

Anonymous Referee #3

Received and published: 22 November 2004

Acpd-2004-0067

Modelling the impact of noctilucent cloud formation on atomic oxygen and other minor constituents of the summer mesosphere authors: B. Murray and J.M.C. Plane

This paper is one of the first dealing with possible changes in the distribution of major and minor odd oxygen and odd hydrogen species in the vicinity of noctilucent cloud layers located over the summer pole between 60° and 90° latitude at 82-84 km altitude. It is of course not unexpected, that the cold temperature environment, the presence of water ice and varying solar UV radiation could have a marked effect on the distribution of photochemical active species in particular atomic oxygen and the short live species like OH, OH2 and H2O2. Nevertheless such studies were not done so far for the cold mesopause region and the presence of solid ice.

The study is based on new results of atomic oxygen adsorption from lab measurements of the same group, the outcome of most recent modeling work for the formation of noctilucent cloud particles by Berger and von Zahn, and the results of in-situ rocket measurements of atomic oxygen showing pronounced depletions at the NLC height and the positive ion measurements by Kopp and Arnold with indications of unusual enhancements in the odd hydrogen species such as H2O2, which were so far not really explainable.

The authors have studied three mechanisms in order to explain changes in the atomic oxygen density, namely a) the catalytic removal of atomic oxygen on NLC ice particles, b) photolysis of water vapor at the base of NLCs where fast evaporation process of water vapor takes place and c) an enhancement of odd hydrogen by photochemical processes also at the base of NLCs and the related depletion of ozone and atomic oxygen.

All three processes were carefully studied in a 1 D-model (MESMOD) at two different local times (0200 and 1400 LT). With the inputs of new measured turbulent Eddy Diffusion coefficients by Luebken and coworkers the model results of the atomic oxygen profiles could be compared to measured results from earlier rocket borne measurements.

The authors were able to give lower limits for the uptake coefficients (gamma) of atomic oxygen on solid NLC ice particles and obtained with their model a value, which was almost four orders of magnitudes larger than, found in their earlier lab measurements. The atomic oxygen depletion at the height of NLCs observed in most of the rocket measurements is thus not related to a heterogeneous chemical process odd O at the surface of ice particles.

Further photochemical modeling of the odd hydrogen and odd oxygen taking into account the changes of water vapor concentrations in the vicinity of an NLC (depletion above, enhancement below), gave enough evidence for an enhancement of all odd hydrogen species in particular H2O2 and a related depletion of ozone below the NLC height and the associated effect of atomic oxygen depletion at the height of NLC (82-84 km).

The paper is well structured and all inputs to their modeling work well documented, explained and justified. Although a 1 D model is not appropriate anymore to study the build up and transport of NLC particles it is of course suitable to study short time photochemical processes related to a redistribution of minor constituents with varying solar zenith angle.

Almost nothing has been published to study the effect of solid ice particles and low temperature on the abundance of odd oxygen and hydrogen so far. Therefore this paper opens a new and important outlook for new measurements in the lab and for ideas for dedicated measurements with sounding rockets and should give as well new ideas for further modeling efforts. The conclusion reached in this paper is unexpected but certainly substantial and most probably correct. Some of the references mainly in the introductions do not give enough credit to earlier work and will have to be updated (see details at the end). The presentation is in general well written and understandable. However, a few parts have to be rephrased (see details at the end). The title is well chosen. The authors should consider adding "polar" in front of mesosphere. The abstract is a good summary of the results presented in the paper. The mathematical formulae, symbols etc. are correctly used. I have also not found a misprint in the equations.

All figures do represent the results of measurements and modeling well. However, Figure 4 is at the lower limit for a good reading. I suggest using a slight enlargement for this figure. The text is in Arial and the figures are numbered and labeled in Times Roman, maybe the editors do not like this.

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Details:

Introduction: page 7181 line 25: Delete reference Gadsden and Schröder (1989) and include the first references related to the formation of NLC ice particles by nucleation of water vapor: E. Hesstvedt (1969), Nucleation and growth of noctilucent cloud particles, Space Research IX North Holland, Amsterdam p. 170-174. The first good model work on ice particle formation was done by G. Reid (1975), Ice clouds at the summer polar mesopause, J. Atmos. Sci. 32, p. 523-535. You could consider adding this reference as well.

Introduction page 7182 line 3: Observations from space (PMCs) date back to: a) Donahue, T.M., B. Guenther, and J.E. Blamont (1972), Noctilucent clouds in daytime, circumpolar particulate layers near the summer mesopause, J. Atmos. Sci., 29, 1205-1209. And b) G.E. Thomas and J.J. Olivero (1986), The heights of polar mesospheric clouds, Geophys. Res. Lett. 13, 1403-1406.

I suggest replacing Hervig and Debrestrian and adding the earlier PMC references.

Page 7184 Lines 1-9: The authors should consider adding a reference to this part.

Page 7187 line 21: space missing between a and Kzz Same page line 22: Kzz is not derived from density measurements alone it is derived from a fast measurement of the density and its fluctuation.

Page 7188 lines 7-10: The sentence "This was because using .... " is not well understandable and should be rephrased.

Page 7189 line 4: I would slightly change this sentence: Below 83 km, the modeled [O] is around 4x10**8 cm-3 and lies within the range of measurements.

Page 7189: line 14: I suggest to add after OHx the word family.

Page 7192: line 14: rephrase the sentence "That is, (greek gamma) would need ...

Page 7192: line 21: give an altitude of the mesopause (88-90 km)

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Page 7192: lines 24-26: take out "after nucleation" in order to avoid a misunderstanding.

Page 7193: line 1: give a lower limit size of visible NLC particles (r $>$ 25 nm)

Page7194: line 18: Unit (cm2, cm-3) is not understandable change to (cm-1).

Page 7185: line 17: The sentence "At 83 km, there is predicted ..." is bad English, please improve.

Page 7197: line 25: delete misprint t in front of symbol (greek Chi).

Fig. 4: It could be that the model O profile in both figures does not match the local time 12:00 and 24:00 used for the odd hydrogen family (I assume that O is modeled for 02:00 LT and 14:00 LT).

Fig. 6b: The unit of Mie absorption should be changed to cm-1.

Fig. 7: The caption should include $>$= after the uptake coefficients and a reference to table 1 for the profile c and e for better understanding.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 7181, 2004.